

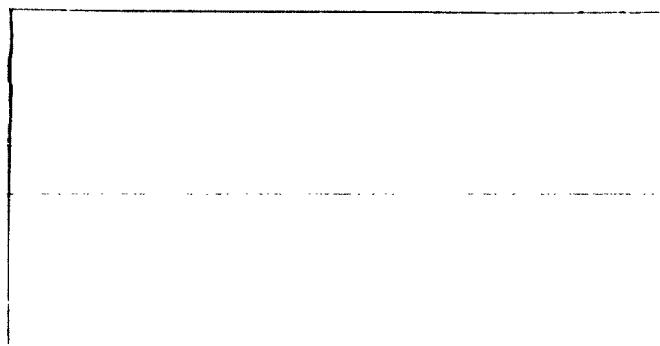
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INTERIM DEVELOPMENT REPORT
FOR
RESEARCH AND DEVELOPMENT TO IMPROVE
THE RESOLUTION OF
IATRON DIRECT VIEW STORAGE TUBES

This Report Covers the Period November 22, 1962 to February 22, 1963

Navy Bureau of Ships Electronics Division
NObsr-87264 SR-00803, Task 9497

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APPENDIX I The Magnetic Microlens as it Pertains to the Iatron Resolution Problem

1.0 PURPOSE

The purpose of this research and development is to improve the resolution of Iatron Direct View Storage Tubes, as follows:

- a. Conduct studies and investigations on the electron optical design of the image section to effect resolution improvement, as specified below:
 - 1. Electrostatic "microlens" principle of focusing each mesh aperture of the storage screen onto the phosphor by its individual lens;
 - 2. Magnetic "microlens" principle of focusing each mesh aperture by its localized magnetic field;
 - 3. Gross magnetic focusing as in storage image tubes but with additional provision for effecting scan.
- b. Develop and construct experimental samples with the following objectives:
 - 1. Brightness at saturation in a 5-inch Iatron operated at 8.5 kv shall be a minimum of 4000 foot-lamberts.
 - 2. Resolution at 50 percent saturation brightness (by shrinking raster method) shall be a minimum of 100 raster lines per inch at the tube center.
 - 3. Other tube parameters should equal or exceed those specified in MIL-E-1/1337 (Navy).
- c. Improve technology of complex meshes.

Abstract

Three general approaches were pursued during this quarter year. They were:

- a. Electron-optical bench
- b. All-magnetic Iatron
- c. Magnetic microlens

Electron optical bench work was concluded with positive results. It indicates that resolution improvement can be obtained by the addition of a focus electrode in registry with, and on the phosphor side of the backer electrode. Information on the brightness obtainable in such a tube will be available only when mesh fabrication technology is achieved for the inclusion of such a mesh in an operating Iatron.

The prototype all-magnetic Iatron has demonstrated resolution well in excess of the contract objectives. Brightness of display in this tube was severely reduced by lack of a properly designed flood gun. Nothing inherent in the magnetically focused tube prohibits high brightness, given a properly designed flood gun.

Consideration of the magnetic microlens option for resolution improvement has introduced technical and theoretical difficulties which, in the limited time left in this study, are serious enough to justify a suspension of that effort.

2.0 GENERAL FACTUAL DATA

2.1 Personnel and Hours

Engineers

R. Clayton	323.7 hours
K. Crowe	526.0 hours
D. Davis	22.0 hours
R. Ryan	112.0 hours
G. Papp	50.0 hours
M. Toohig	28.0 hours

Others	34.7 hours
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Support Personnel	683.5 hours
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2.2 Figures

1. Schematic Drawing of the Complex Mesh.
2. Relative Positions of Bench Electrodes
3. Mesh Electrode Disk
4. Foci of Complex Mesh at Fixed Signal Voltage
5. Modulation of Complex Mesh at Fixed Focus Voltage
6. Modulation of Simple Mesh
7. Magnetic Iatron Image Section
8. Stored Line Width at Points of Focus
9. Actual Form of Stored Line Width Curves

2.3 Tables

- 1. Magnetic Iatron Design Values**
- 2. Width of Stored Line**

3.0 DETAILED FACTUAL DATA

3.1 Electron Optical Bench

The objectives of the work conducted on the electron-optical bench were to demonstrate electrostatic microlens focusing action and to determine design parameters applicable to the construction of an image section which would render improved Iatron resolution. While the feasibility of the complex mesh approach to the Iatron resolution problem can be shown only in an actual Iatron and not in a model, the results of this experiment are encouraging. A schematic drawing of the complex mesh geometry is given in Figure 1. Sections A and B of Figure 1 are similar to the standard Iatron storage mesh. Section C provides electrical insulation between the backer electrode (B) and the focus electrode (D). The purpose of the focus electrode is to focus the flood gun current, as it travels through a mesh aperture, to a circle of minimum confusion at the phosphor.

3.1.1 Review of Bench Construction

Although the electron-optical bench has been described in the second quarterly report of this contract, with revisions reported in the third quarterly report, a brief review of the equipment will be given here. The bench consists of a vacuum system which is equipped with a removable cylindrical chamber, a phosphor coated glass disk, a complex mesh simulator assembly, collector and calibration meshes, and ring electrodes. The ring electrodes insured that a known gradient would be maintained along the axis of the tube. The electrodes of the tube were spaced so that an Iatron was simulated at a scale of 200 to 1. Figure 2 shows the relative positions of these components as they were used to simulate the Iatron.

3.1.2 Complex Mesh

The complex mesh assembly consists of three electrodes; namely, the insulator, backer, and focus electrodes. These electrodes were constructed by placing together two or more of the disks shown in Figure 3. Although the disks were separated by lava spacers, a common voltage was applied to that set of disks which represented any single electrode. This scheme gave a simple method by which relative electrode thicknesses could be varied. Also, it was an easy task to add or subtract a disk and hence to change the total mesh assembly thickness. A Sparkatron was used to etch the square apertures into the disks.

3.1.3 Collector Mesh

The collector mesh was placed near the complex mesh assembly described above. The function of the collector mesh was to simulate the gradient found between collector and insulator in standard Iatrons. In an actual Iatron, the collector

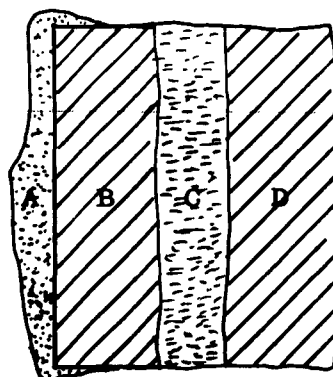
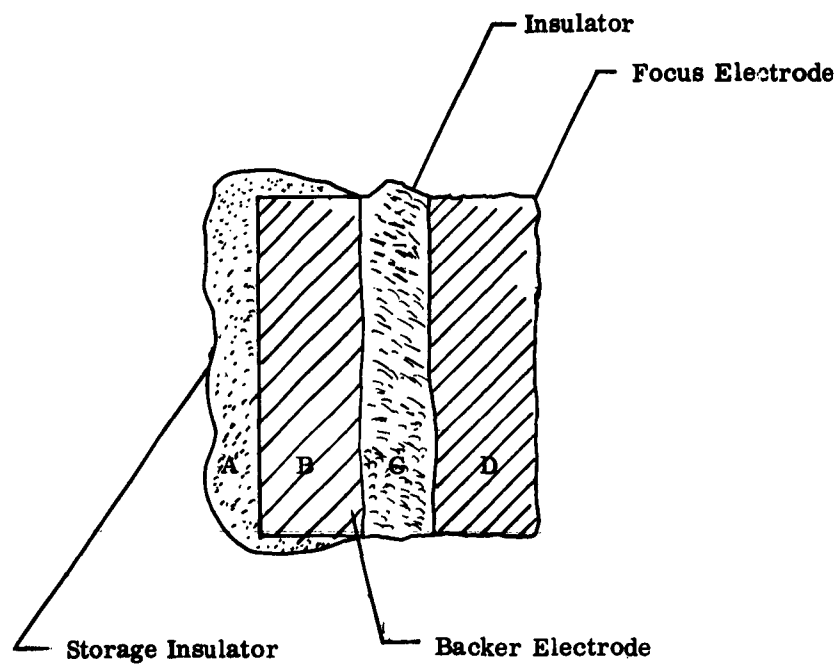


Figure 1 Schematic Drawing of the Complex Mesh, Showing One Mesh Aperture

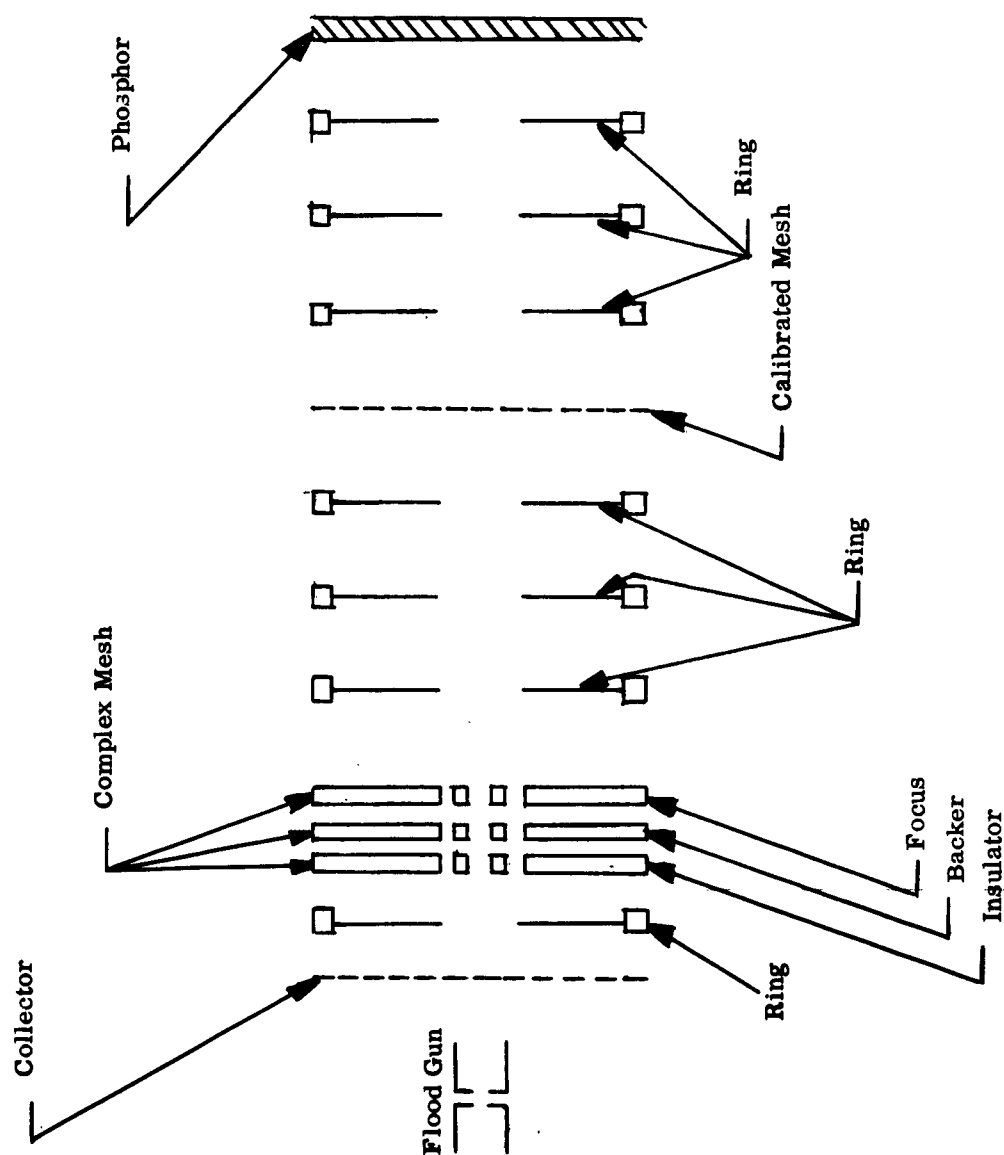


Figure 2 Relative Positions of Bench Electrodes

is used to collect secondary electrons that are generated by the writing gun electron beam as it stores a signal on the insulator mesh. However, the secondary emission method of storing a signal was not used in this experimental model because it was much easier to eliminate the insulating material and simulate signal voltages with a battery. The use of a battery also made the problem of an exact determination of insulator potentials easier.

3.1.4 Calibration Mesh

A calibration mesh was located midway between the phosphor and the complex mesh assembly. The purpose of this mesh was to provide a method by which the magnitude of the radial velocities of the electrons could be measured. As has been described in previous reports (first quarterly report) each aperture of an Iatron storage mesh forms a converging lens whose focal length is of the order of the dimensions of a mesh aperture. The focusing action of the mesh lenses causes a deviation from the ideal electron trajectories, i. e., paths parallel to the tube axis, by imparting on the electrons a radial velocity. It is this radial velocity that degrades Iatron image section resolution, and with a fixed electron transit time from insulator to phosphor, one must reduce this velocity if resolution is to be improved. It is desirable to measure the radial velocities of the peripheral electrons (electrons that traveled near the edges of the complex mesh apertures) at different values of focus electrode voltage. In practice, this measurement was considered too difficult to be meaningful considering the equipment that was used. The calibration mesh was not, however, removed from the assemblage since it served to establish the proper gradient adjacent to the complex mesh. The gradient before the calibration mesh, between calibration mesh and complex mesh, was set to simulate 30 volts per mil - representative of Iatron gradients found between storage mesh and phosphor. The gradient on the phosphor side of the calibration mesh was much higher (representing 600 volts per mil). This gradient was chosen so that the tube could be shortened. If the scaled 30-volt per mil gradient was used throughout the entire length between complex mesh and phosphor, this distance would have been much too large to be contained in the vacuum chamber that was available. It is believed that this change in gradient did not seriously affect the results of the experiment.

3.1.5 Effects of Focus Voltage

Figure 3 is a photograph of one of the eight disks used to simulate a complex mesh. It is shown in the same scale as are the phosphor displays of Figures 4, 5 and 6. Nine holes were used as it was felt that a single aperture lens would behave quite differently from one surrounded by similar lenses.

Figure 4 shows the effect of varying the focus electrode potential through a range of 8 volts in a representative experimental set-up. In Figure 4a, the elemental

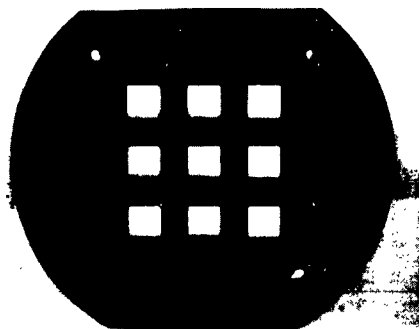
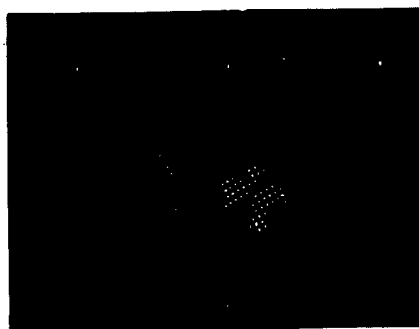
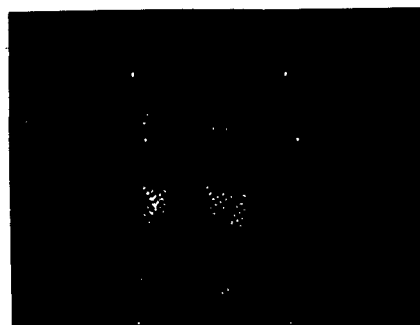


Figure 3 Mesh Electrode Disk



a



b



c



d

Figure 4 Foci of Complex Mesh at Fixed Signal Voltage

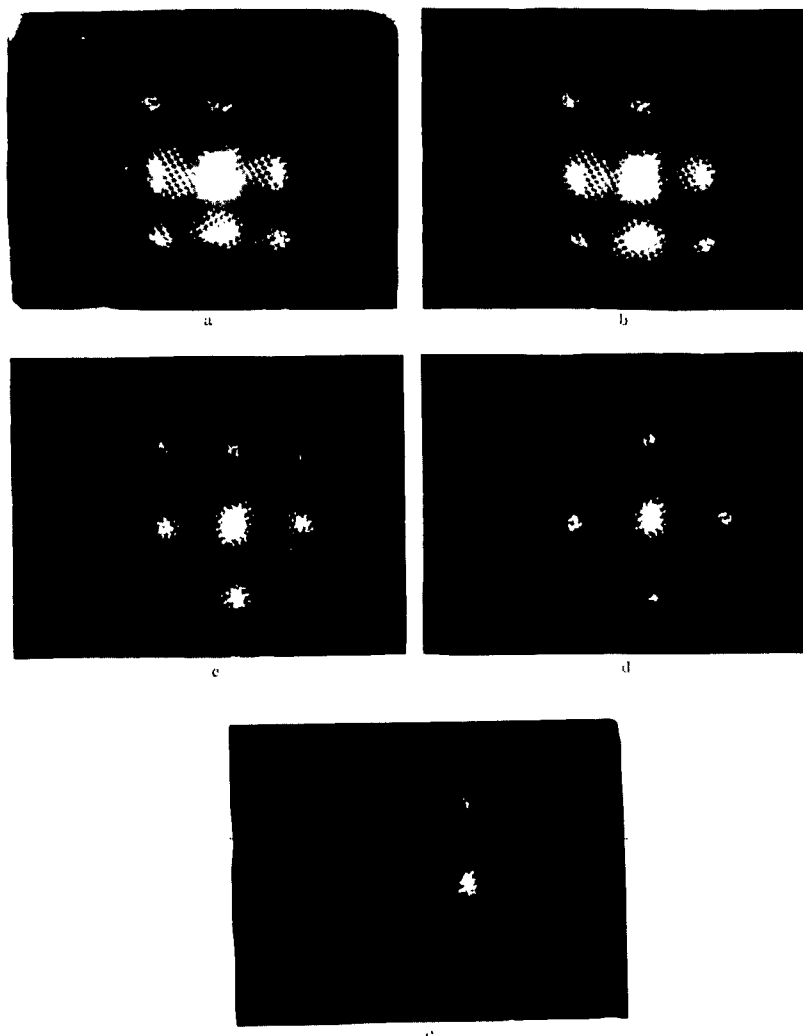


Figure 5 Modulation of Complex Mesh of Fixed Focus Voltage

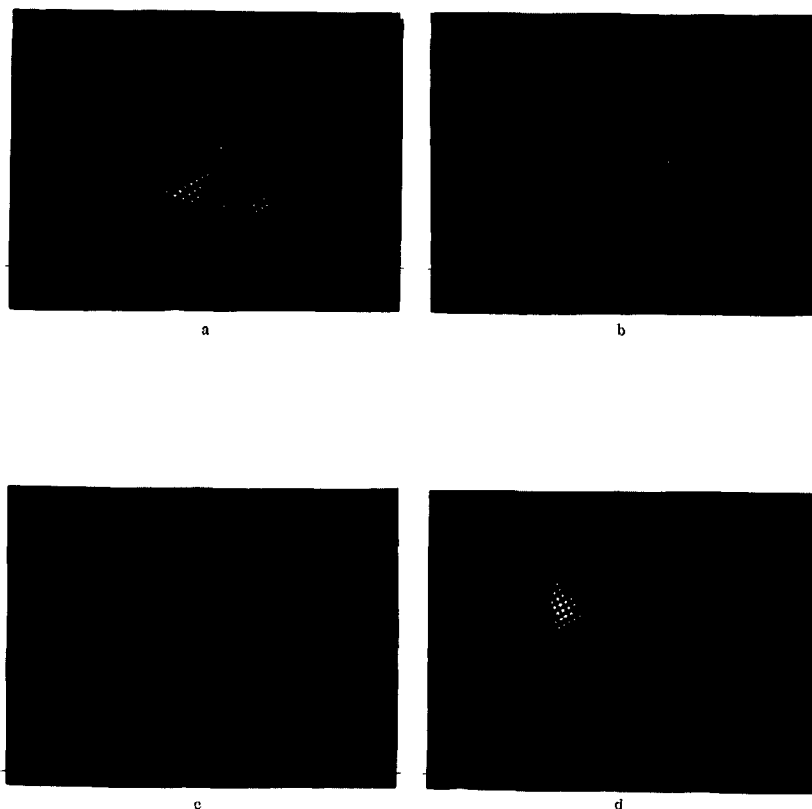


Figure 6 Modulation of Simple Mesh

electron bundle is diverging. Comparison of the width of the central "square" with the corresponding dimension of the aperture plate (Figure 3) indicates that adjacent electron "bundles" should now be overlapping. The fact that the outer apertures are missing next-neighbors appears to prevent similar divergence on their part, hence their images are less than tangent to that of the surrounded central aperture. In successive photographs (Figures 4b, c and d), focus electrode voltage is increased and the image generally becomes smaller and distorted until, in Figure 4d, the square apertures are projected as crosses. The backer and insulator electrode voltages remained constant at 30 and -1.5 volts respectively. The focus electrode voltages corresponding to the four photographs are as follows: 4a, 2 volts; 4b, 4 volts; 4c, 6 volts; 4d, 10 volts. These photographs demonstrate the focusing properties of the complex mesh assembly.

The radical change in the image (from a square in Figure 4a to a cross in Figure 4d) is because of the focusing properties of a square aperture. A square aperture is astigmatic in that the focal length of those electrons that pass near the corners of the square is different from a focal length of electrons that pass near the edge of the square. Figure 4a shows that the electrons from the aperture edges are less divergent than those from the corners. In Figure 4b the edge electrons are approaching focus and the image of the corners of the aperture are starting to be focused. Figure 4c shows a condition where both the corners and edges of the aperture image are focused and Figure 4d shows the edges over-focused while the corners remain focused.

Figure 3 was included to give the reader an idea of the scale of the photographs. The sides of the square apertures are 9/32 of an inch long. The reader should not place too much emphasis on the relative brightness of the photographs as constant exposure time was not maintained in Figures 4, 5, and 6.

3.1.6 Dynamic Range of the Insulator

Figure 5 consists of five photographs in which the effects of changing the insulator electrode voltage are shown. Backer and focus electrode voltages remained constant at 40 and 15 volts respectively. The purpose of this set of photographs is to demonstrate that the focus electrode accomplishes its function throughout the entire range, from zero volts to cut-off, of insulator voltages. In an Iatron, the focus voltage would be chosen so that focus occurred when the insulator voltage permitted maximum flood electrons to penetrate the mesh. The reason for this choice is that resolution is worst at zero insulator voltage. The photographs of Figure 5 show that the format of the image of the center aperture of the mesh assembly remains essentially unchanged, except for a shrinking of the projected area which can be attributed to the "pinch effect" at the storage surface, throughout the entire range

of insulator voltages. The "pinch effect" is a reduction in the effective area of an aperture caused by a retarding field surrounding the aperture. Note that as the insulator voltage approached cut-off, the outer apertures were cut-off before the center aperture. It is believed that this effect is due to poor collimation of the flood gun. This effect should not, however, detract from the results obtained by observing the center aperture.

3.1.7 Standard Mesh Iatron

In order to have some comparable data between the standard and complex storage meshes, photographs were taken in which a standard storage mesh was simulated. Insulator and backer electrodes were each simulated by placing four disks in direct contact without intervening lava spacers. The focus electrode was omitted. The photographs of Figure 6 were taken as the insulator voltage was varied from zero to cut-off (-3 volts). It is apparent that the mesh aperture projections are magnified more in these photographs than in Figures 4 and 5. While this fact is indicative of improved resolution by the use of a focus electrode, it is not conclusive. As was stated previously, the results of this experiment are encouraging and certainly further work is justified in the construction of a complex mesh assembly that can be tested in an actual Iatron.

3.2 Gross Magnetic Focus

In order to explain the results of testing which has been performed during this quarter on the all-magnetic Iatron, we will recapitulate some of the thinking which preceeded the construction of the prototype tube.

The philosophy of design is best expressed in the abstract of Appendix II to the first quarterly report (period February 22, 1962 to May 22, 1962), which reads, in part:

"Flood electrons, which approach the Iatron storage mesh essentially parallel to the tube axis, are focused very close to the mesh plane by individual aperture lenses and subsequently diverge to a large "circle of confusion" at the phosphor screen. Iatron resolution may be improved by reconvergence of these elemental beams at the phosphor. One means of accomplishing this refocus is by use of an axial magnetic focus field extending from the storage mesh to the phosphor."

The referenced report goes on to describe the difficulties involved in terminating the image section magnetic focusing field so as to exclude write and flood guns from it. The recommendation of that report is to build and test an all-magnetic Iatron which includes write and flood guns within an extension of the image section

focus field. Such a tube was built in the subsequent quarter, and has now been evaluated.

3.2.1 Image Section Performance

By image section, we refer to that portion of the all-magnetic Iatron extending from the backer (insulator support) mesh through the phosphor. The image section contains a field mesh parallel to both the phosphor and backer mesh planes, but positioned nearer to the phosphor. Between the field mesh and the backer mesh are six electrically conducting rings equally spaced and, in operation, equally subdividing the potential difference between these elements. Figure 7 is a schematic representation of the image section. It may be seen in perspective by comparison with Figure 1, Page 4 of the Quarterly Report for the period ending August 22, 1962.

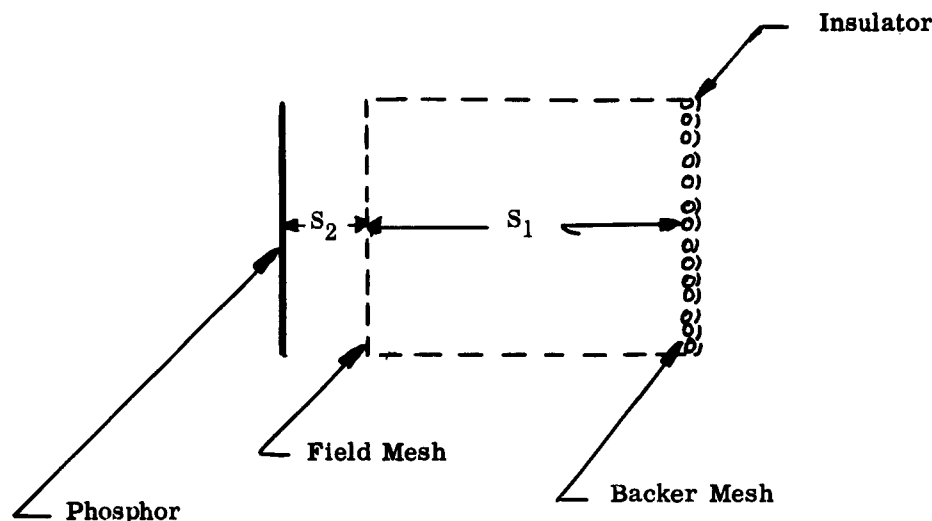


Figure 7 Magnetic Iatron Image Section

In Figure 7, S_1 and S_2 represent the distances between backer mesh and field mesh and between field mesh and phosphor, respectively. For purposes of design we may approximate the focus field required, by computation from the potential of the field mesh (ϕ_1) and its distance (S_1) from the backer mesh. The error of this approximation will be the ratio of transit times through section S_2 and through the entire scan section. This may be expressed mathematically:

$$\% \text{ Error} = \frac{T_2}{T_1 + T_2} \times 100 \quad (1)$$

Assuming that electrons start from the backer mesh with negligible initial velocities, the transit time (T_1) through space S_1 may be expressed as

$$T_1 = \frac{2 S_1}{K \sqrt{\phi_1}} \quad \text{where:} \quad (2)$$

$$K = \sqrt{2 \frac{e}{m}}$$

ϕ_1 = potential of field mesh

Transit time (T_2) through space S_2 becomes

$$T_2 = \frac{2 S_2}{K (\sqrt{\phi_2} + \sqrt{\phi_1})} \quad \text{where:} \quad (3)$$

ϕ_2 = phosphor potential

In the prototype tube, the following design values were chosen:

Table 1

Magnetic Iatron Design Values

$$S_1 = 3\text{-}3/8 \text{ inches}$$

$$S_2 = 5/16 \text{ inches}$$

$$\phi_1 = 1200 \text{ volts}$$

$$\phi_2 = 8500 \text{ volts}$$

Substituting the values from Table 1 into equations 2 and 3, and, in turn, substituting equations 2 and 3 into equation 1 yields:

$$\% \text{ Error} = 2.5\% \quad (4)$$

For lower values of ϕ_1 , the error will be less. Therefore, in calculating the magnetic field strength, we will ignore region S_2 .

In practice, because of limitations in the deflection supply circuits, the magnetic focus field was operated at considerably less than the 45 gauss originally intended. This necessitated reduction of the image section field mesh potential well below the intended 1200 volts. The highest field mesh potential at which single loop focus could be obtained consistent with reasonable deflection amplitude was, in fact, 520 volts. This indicates a magnetic focus field of

$$B = \frac{4.17 \sqrt{\phi_1}}{L} = \frac{4.17 \sqrt{520}}{3 \frac{3}{8}} \quad (5)$$

$$= 28 \text{ gauss}$$

At 28 gauss focus field, we were able to measure a stored raster line width of 8 mils. Resolution appeared to be dictated by the write gun rather than by any inherent image section limitation. Moreover, the measured 8-mil line width was at 100 percent modulation.

A second resolution determination was made with a stronger focus field (approximately 42 gauss). In this operating mode, a stored raster line width estimated at 6 to 7 mils was observed. Shrinking raster evaluation of this resolution yielded approximately 170 raster lines per inch. The exact percent modulation in this measurement could not be determined owing to equipment limitations. The tube was considerably underscanned. We do not know whether increased beam velocity or field intensity might have further increased resolution, but we were fast approaching the resolution limit imposed by the 250-line per-inch storage mesh.

3.2.2 Scan Section Operation

In paragraph 3.2.1, mention was made of operation at two focus field intensities; 28 and 42 gauss. These values were measured in the image section. A recalculation of the fields based upon scan section measurements yields slightly different values; 30 and 42 gauss. The tube was operated in each of these fields at different write gun electron velocities, and the width of resulting stored raster lines measured.

A graphical presentation of these data is given in Figure 8. This is, actually, a plot of measured line width as a function of $(\phi)^{1/2}$ at focal points. The points are measured data. The connecting curves serve only to group the foci of each field strength.

Table 2
Width of Stored Line

<u>Focus Field (B)</u>	<u>Av. Beam Potential (ϕ)</u>	<u>(ϕ) $^{1/2}$</u>	<u>Number Loops (n)</u>	<u>Line Width</u>
30 gauss	150 volts	12.2	3	14 mils
30 gauss	320 volts	17.9	2	10 mils
30 gauss	1350 volts	36.7	1	8 mils
42 gauss	180 volts	13.4	4	9 mils
42 gauss	312 volts	17.6	3	7-8 mils
42 gauss	650 volts	25.5	2	6-7 mils

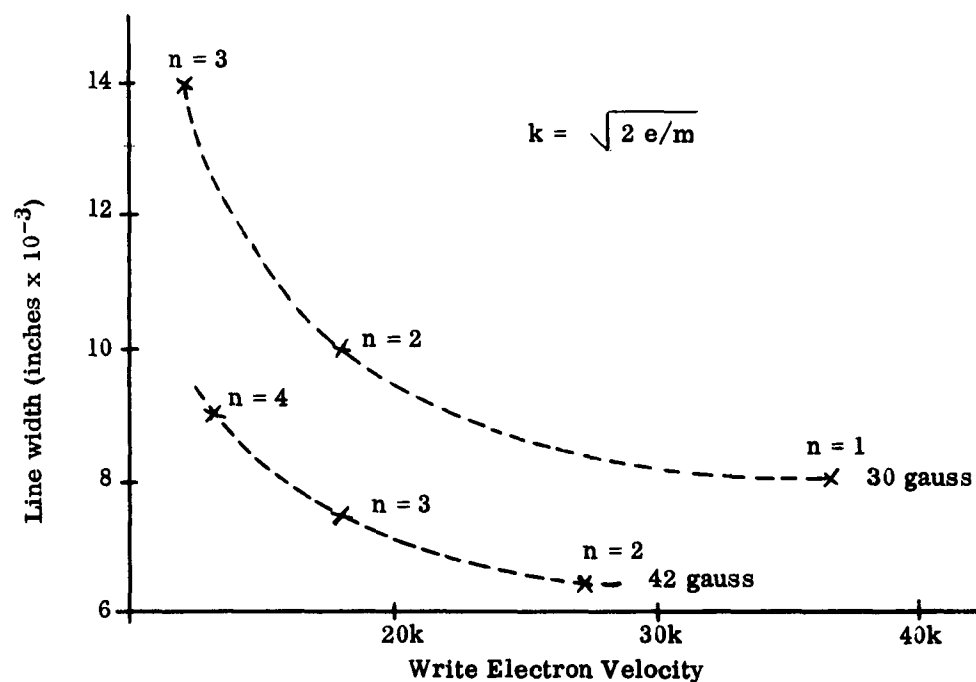


Figure 8 Stored Line Width at Points of Focus

Had the resolution data been taken for every point between nodes of focus, Figure 8 would be a periodic presentation of line width - versus - write electron velocity in the form:

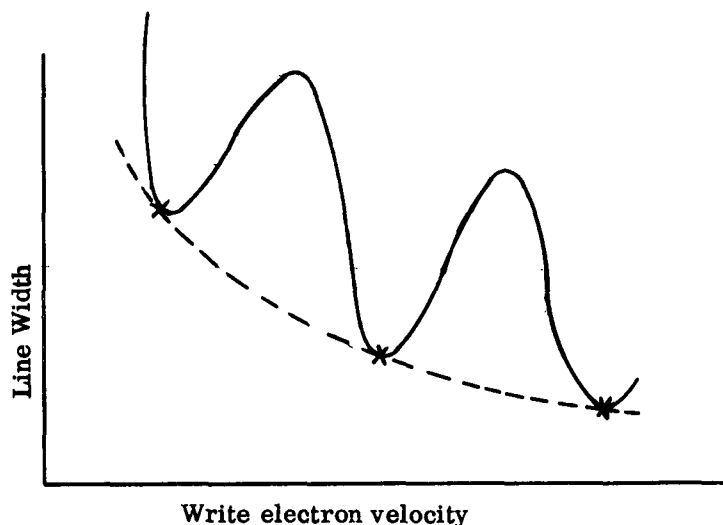


Figure 9 Actual Form of Stored Line Width Curves

The amplitude of the periodic line width function is the diameter of the magnetic focus loop at the insulator, and is a function both of the radial component of electron velocity and the magnetic field strength.

The fact that observed resolution improved at fixed magnetic focus field with increasing write electron velocity in the scan section, indicates that over-all resolution was limited by the write beam diameter rather than by the microlens action associated with the storage mesh. The improvement in observed resolution caused by increasing focus field strength may be attributed to either write beam or image section improvement or both. One fact, however, is apparent. The contract objective of 100 raster lines per inch (corresponding to approximately 10-mil line width)

is easily obtainable in the prototype all-magnetic tube, even at 30-gauss focus field. Moreover, this resolution is obtained in the worst operating condition; at 100 percent saturation brightness. Here, the storage mesh microlenses produce maximum radial acceleration for flood electrons; hence, the largest circle of confusion.

But the objectives of the contract are 100 raster lines per inch at 50 percent saturation brightness, and saturation brightness of 4000 foot-lamberts at 8.5 kv phosphor. While the resolution objective was met in our first all-magnetic tube, our saturation brightness fell considerably short. This deficiency will be discussed in the following section.

3.2.3 Flood Gun Performance

The all-magnetic Iatron makes use of a scanned flood gun which is concentric with the write gun. As a convenience in construction of the prototype, a ring-type flood gun, used in the FW229 Iatron was chosen. While this choice saved design time and the expense of tooling a new flood cathode, it was, in a sense unfortunate. One difficulty caused by the ring gun was a reduction in display brightness. The ring gun is designed for use in an all-electrostatic flood system where electrons require a large lateral acceleration in order to spread them over the entire display area. When this flood gun is included in a tube using an axial magnetic focus field, the lateral acceleration results in a large helix or "corkscrew" trajectory of flood electrons as they approach the storage mesh. At the storage mesh, two effects contribute to reduction in the transmission of spiraling electrons.

- a. Electrons with large velocity components parallel to the mesh approach it at rather high angles, and the mesh becomes opaque to them.
- b. As the flood electrons at any point in space have essentially the same total velocity (assume $eV \gg KT$), those with large spiraling components have lower axial velocity, and are less able to overcome the retarding field produced at the storage surface. An obvious improvement in tube design would be a flat flood cathode with only planar accelerating equipotentials.

At first consideration, one wonders whether the excellent resolution observed in the prototype all-magnetic tube might be degraded once the appropriate brightness is restored. The answer lies in whether or not space charge in the image region changes resolution.

A test was conducted in a conventional Iatron wherein, at a given stored signal level, resolution was measured over a wide range of flood current densities. Current density was varied by means of a triode flood gun, and apparent brightness maintained at a fixed level by duty cycling the flood gun. The latter precaution served two purposes. It stabilized ion-writing problems, and it ruled out measurement error due to physiological factors. The result of this experiment indicated freedom from space charge effects over a range of phosphor currents to 525 ua, and at potentials much lower than those encountered in practice. In summary, there is little reason to doubt that the indicated resolution can be maintained at objective display brightness.

3.2.4 Erase Duty Cycle

Additional experimental difficulty was created by the ring flood gun in the operation of a continuously erased display. In conventional Iatrons, erase pulses may be applied at any convenient rate above the "flicker frequency". In the case of a flood gun which is scanned, however, erase pulses must be at a much higher rate, or may be applied as a continuous pulse during retrace. If the usual erase pulse train is applied, a stroboscopic track of the path of the scanned flood cathode image is superimposed upon the displayed image. Where a solid flood cathode is used, erasure during the "live" (versus retrace) time may be achieved by employing a pulse repetition rate which is some multiple of the scan frequency. In the case of the ring flood cathode, this multiple becomes prohibitively large. These problems need not limit the usefulness of scanned flood-gun devices, but rather illustrate the difficulties of testing such tubes in existing facilities.

3.2.5 Write Gun Performance

Resolution performance of the write gun has been discussed previously in Section 3.2.2. In the prototype tube, an existing (FW245) write gun was used for convenience. Despite the fact that its performance achieved the desired resolution, we feel much improvement can be expected from an electron gun specifically optimized for this tube. No measure of writing speed was attempted during this period, but the freedom of choice in write electron velocity provided by magnetic focusing should permit us to write at the maximum secondary emission potential of the insulator chosen, assuring writing speed equal to or better than in electrostatic types.

3.3 Magnetic Microlens

Magnetic microlens work has been concluded. The approach has not been ruled out, but the remaining time is too short, and alternative approaches too attractive to justify a continuation of this investigation. A summary report of

this investigation is attached as Appendix I.

3.4 Complex Mesh Fabrication

Complex mesh fabrication techniques are under development. To date, no real successes have been achieved, but several new ideas are being tried.

4.0 CONCLUSIONS

4.1 Electron Optical Bench

Tests on the simulated complex mesh indicate that definite resolution improvement can be achieved by the introduction of an additional focus electrode. The additional electrode is located between the backer mesh and the phosphor. No estimate can be made in the scaled optical bench of the brightness loss resulting from such a mesh design. This determination must be made in an actual Iatron tube. Such a tube will be built when mesh fabrication technology permits. If high brightness at high resolution is realized, then the electrostatic microlens solution will be adopted as a final design. This choice will be made despite the apparent advantage of the all-magnetic Iatron in terms of resolution. Whereas the all-magnetic solution is limited to smaller diameter tubes, the electrostatic microlens is equally applicable to all sizes.

4.2 All Magnetic Iatron

Despite test equipment limitations, and an unfortunate choice of conventional flood and write guns, the prototype all-magnetic Iatron was a qualified success. The contract objectives are:

- a. Saturation brightness of 4000 foot lamberts
- b. Resolution at 50 percent saturation brightness of 100 raster lines per inch.

Because of the particular flood gun used in the prototype tube, brightness fell short of the objective. It is believed that, with a specially designed flood gun, brightness can be made to approach or reach 4000 foot lamberts.

Resolution well in excess of 100 raster lines per inch at 50 percent saturation brightness was demonstrated. In fact, this resolution was exceeded at 100 percent saturation brightness.

4.3 Complex Mesh Fabrication

Scheduling problems delayed the start of this phase of the work. No positive results are available at this time, but efforts are being directed along two parallel paths. Much background work has already been accomplished on company sponsored programs.

4.4 Magnetic Microlens

An investigation of the present state of knowledge and technology has been concluded. While the approach holds promise in theory, its complexity does not encourage further study at this time.

5.0 WORK FOR NEXT INTERVAL

5.1 Mesh Fabrication Study

Work will be done in an attempt to construct a practical complex mesh. Two approaches are available. The first approach is to form an electrically independent metallic electrode on a pretreated mesh assembly. The second technique involves the mechanical alignment of two preformed meshes. This alignment is made feasible by a proprietary process. The meshes produced by the most satisfactory approach will be tested in an Iatron.

5.2 Special Materials Study (Confidential)

Testing of negative numerical aperture fiber optics disks will be completed. These disks will be tested in an Iatron.

5.3 Comparison of Iatrons

All Iatrons constructed on this project will be compared, and a decision made on their relative merits.

5.4 Final Tubes

Two tubes using the final design will be constructed and tested.

5.5 Final Report

A final report will be written and issued.

Appendix I

Research Memo No. 372

The Magnetic Microlens as it Pertains to
the Iatron Resolution Problem

Kenneth R. Crowe

February 1963
Revised March 1963

1.0 SUMMARY

Work on the magnetic microlens approach to the Iatron resolution problem has been discontinued. There are two reasons for this action. The first being that it is questionable that the magnetic lens could be made strong enough to be effective and secondly, that construction of the mesh would be difficult and expensive. These problems will be discussed in more detail below.

2.0 FEASIBILITY OF THE MAGNETIC MICROLENS APPROACH

The magnetic microlens was to be used to compensate for the effects of the electrostatic lens found at each insulator mesh aperture. Reference to Figure 1 will help show this point. The magnetic lens was to focus the electrons at the primary focal point of the electrostatic lens. This would allow the electrostatic lens to direct the current to a collimated flow as shown in Figure 1. If this scheme could be accomplished the resolution would be limited by the dimensions of the mesh apertures. In practice, however, the width of the writing gun electron beam must be minimized if this limit is to be attained. The problem with this plan is that the sum of the focal lengths of the two lenses must be of the order of a mesh thickness (approximately 1 mil). To meet this requirement the focal point of the magnetic lens must be somewhere within the mesh. It is believed that this restriction places great strain on the feasibility of the approach.

In general, the focal length of a magnetic lens is a function of the magnetic field strength and velocity of the electrons traversing the lens. The problem of expressing these variables as a function of the coordinates of the lens and thereby obtaining a solution to the equation of motion of the electrons, is formidable and will not be attempted. This fact would indicate that experimentation was in order if it were not for other considerations. These considerations are the second reason for discontinuing this phase of the program and will now be considered.

3.0 MESH CONSTRUCTION

The mesh was to be covered with a ferromagnetic material and then magnetized in a direction perpendicular to the plane of the mesh. Obviously, the ratio of the thickness to the diameter of the magnet would be extremely small and theory predicts that as this ratio approaches zero the remanent induction (defined as that induction remaining when the external magnetizing force has been removed) will approach zero. Figure 2 shows the important result of this discussion; which is, that as the remanent induction (B) approaches zero, the magnetic field strength (H) approaches the coercive force of

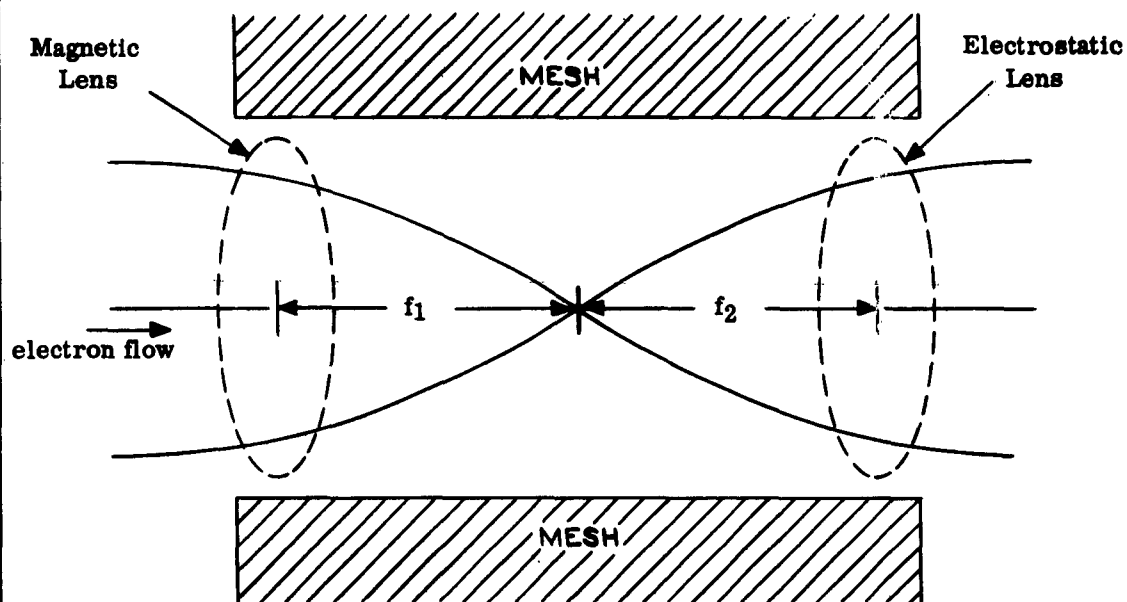


Figure 1. Schematic Representation of the Magnetic Microlens Scheme Showing a Cross-sectional View of a Mesh Aperture.

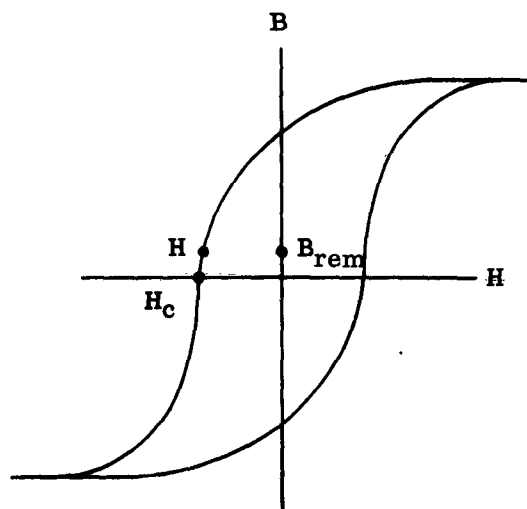


Figure 2. A Typical Hysteresis Loop. As B Approaches Zero, H Approaches H_c .

the material (H_c). Since H remains unchanged across the boundary of a material medium it is evident that the field strength within the mesh apertures at points adjacent to the mesh will be equal to the field strength within the magnet. Furthermore, only materials possessing high coercive forces will produce strong fields within the mesh apertures, and hence these materials will produce the strongest lenses. Unfortunately, materials that have high coercive forces are alloys. Platinum - cobalt, for example, has a coercive force of 2600 oersteds. Since each element of an alloy has a different thermal evaporation rate, the mesh could be covered with a ferromagnetic alloy using an evaporator only after a system had been devised to deposit the correct percentages of the various elements. Even this, however, does not guarantee that the material will possess the properties of the alloy. It is believed that the alloying problem could be solved, but the solution would certainly require expenditures of time and money. It was felt that in view of the other problems given in this report that the effort required to solve the above problem could not be justified. Another fact that must be considered is that the magnetic microlens scheme is not the only available approach to the Iatron resolution problem, and since time and money are limited one must compare the merits of all the possible solutions and concentrate on the most promising.